AN AUTOMATED STATISTICAL DOWNSCALING APPROACH FOR HYDROLOGICAL BASED CLIMATE CHANGE IN HUMID TROPICAL AREA

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To my beloved Father, Mother, Wife

And Daughter

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ABSTRACT

Many Climate Models have been developed to assist scientist to forecast climate changes. The Automated Statistical Downscaling (ASD) model is considered a new recent model to perform this task. The aim of this study is to explore the applications of ASD model in the projection of the future climate changes in humid tropical region. Global Climate Models (GCMs) provides climate impacts information from higher resolution, but there are many impacts require climate information of a smaller resolution. Downscaling is a method to link global scaling prediction to regional prediction. NCEP and CGCM3.1 predictors are used to link these two scales. Multi Linear Regression approach in the ASD model is applied to calibrate NCEP predictors with rainfall data for the period 1961 to 1975 and the results shows that the three stations were calibrated with low RMSE values. The results are validated by using CGCM3.1 and NCEP data for the period 1976 to 1990. The geographic location of the predictors has an influence on the number of predictors available, since the selected station is located within a grid box near the equator making it affected by coriolis effect, limited set of predictors are available. A2 and A1B SRES emission scenarios are used for future projection scenarios for the periods 2011-2040, 2041-2070, and 2071-2100. Five statistical indices that are used namely: mean rainfall, Standard Deviation, 90^{th} percentile, wet days and Consecutive Dry days has been evaluated. A2 and A1B scenarios results shows that certain months will experience an increase in rainfall in terms of intensity and frequency while other months will experience a significant decline.

ABSTRAK

Terdapat banyak Model Iklim telah dibangunkan untuk membantu ahli sains dalam ramalan perubahan iklim. Model *Automated Statistical Downscaling* (ASD) dianggap sebagai salah satu model baharu untuk menjalankan tugas ini . Tujuan kajian ini adalah untuk menerokai aplikasi model ASD dalam unjuran perubahan iklim pada masa akan datang di rantau tropika lembap. Model Iklim Global (GCMs) menyediakan maklumat kesan iklim daripada resolusi yang lebih tinggi, tetapi terdapat banyak kajian kesan memerlukan maklumat iklim resolusi yang lebih rendah. *Downscaling* adalah kaedah untuk menghubungkan ramalan bersisik global kepada ramalan serantau. Peramal NCEP dan CGCM3.1 digunakan untuk menghubungkan kedua-dua penimbang. Pendekatan *Multi Linear Regression* digunakan untuk menentukurkan peramal NCEP dengan data hujan bagi tempoh 1961 hingga 1975 dan keputusan kajian menunjukkan bahawa ketiga-tiga stesen telah ditentukur dengan nilai-nilai *RMSE* rendah. Keputusan kajian disahkan dengan menggunakan data CGCM3.1 dan NCEP bagi tempoh 1976 hingga 1990. Lokasi geografi peramal mempunyai pengaruh ke atas bilangan peramal yang sedia ada , kerana stesen yang dipilih terletak di dalam kotak grid berhampiran khatulistiwa yang menyebabkannya terjejas oleh kesan *coriolis,* hanya set peramal yang terhad boleh didapati. A2 dan A1B, senario pelepasan SRES digunakan untuk senario unjuran masa depan bagi tempoh 2011-2040 , 2041-2070 , dan 2071-2100 . Lima indeks statistik yang telah dinilai iaitu: hujan min, sisihan piawai , persentil ke-90 , hari basah dan hari kering berturut-turut. Keputusan senario A2 dan A1B menunjukkan bahawa bulan tertentu akan mengalami peningkatan dalam hujan dari segi intensiti dan kekerapan manakala bulan-bulan lain akan mengalami penurunan yang ketara.

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LIST OF SYMBOLS

ASD	Automated Statistical Downscaling
CDD	Consecutive Dry Days
GCM	Global Circulation Model
NCEP	National Center for Environmental Prediction

CHAPTER 1

INTRODUCTION

1.1 Introduction

The world climate is experiencing a dramatic change over the last century in terms if temperature, precipitation, ice melting and overall change in weather pattern due to the increasing human activities, which is a main contribution to the change. One example of these activities is a carbon emission. These changes affect the world's different aspects of life such as, economy, environmental impacts and health. In this regard, climate change is continually affecting the earth hydrological cycle, therefore researchers started to find methods to forecast these effect and/or the climatic status in order to find ways of adaption. There are many risks associated with the change of precipitation pattern, in some area the precipitation rate is suffering a major decline leading to draught whereas in some area is increasing creating floods.

One of the major approaches that assisted scientist to forecast changes is the development of atmospheric physics. At early of 20^{th} century, several equations were brought up that predicts large-scale atmospheric motions. General Circulation models (GCMs) is the most advanced numerical modeling tool that simulates the varying effects of the global climate change due to the increasing green house gases.

concentration, this model is three dimensional grid over the glove with horizontal and vertical resolution that includes several variables like pressure, temperature, humidity, wind and water and ice. There are two types of GCMs, atmospheric and oceanic, but when coupled, the result is more complete.

GCMs provides climate change information at a coarser resolution that means many impacts are neglected and to incorporate these neglected impact a finer resolution in required and this can be achieved by downscaling. One of the methods of downscaling is statistical downscaling that has the ability to predict future climatic scenarios and to estimate changes in future hydrological pattern.

1.2 Problem Statement

Precipitation is one of the most difficult weather phenomena that can be predicted, since it depends on many physical processes and these vary from one place to another. There are two ways that climate models can simulate precipitation one by synoptic precipitation system which is the result of air vertical uplift caused pressure system, and the second is convective precipitation system, in which latent heat cause the vigorous uplift of air causing a more a local intense rainfall (Khairul 2011).

Due to the climate instability where floods or draughts are there recent phenomena, it is necessary to forecast rainfall for future decision making that regards water allocation, water storages, and water infrastructures or in one context, water resources management.

The first methods used to predict future climatic scenarios is statistical downscaling which is widely used in tropical regions including Malaysia and it has been used to evaluate changes in hydrological regimes (Khairul, 2011).

1.3 Objectives of Study

The aim of the study is to explore the applications of the Automated Statistical Downscaling (ASD) model in the projection of the future climate changes in humid tropical region. The objectives of the study are as following:

1) To calibrate rainfall data from selected stations in humid tropical area.
2) To simulate rainfall by using ASD model that links local daily precipitation with large scale variables.
3) To evaluate the hydrological characteristics of rainfall data simulated from ASD.

1.4 Scope of Study

The aim of this study is to simulate rainfall for three selected stations in Pahang region in Malaysia using existing data of precipitation as predictands by using Automated Statistical Downscaling ASD model for the three selected stations. Daily time series rainfall data obtained from Department of Drainage and Irrigation, Malaysia, at a single station (daily precipitation, maximum, minimum and total) and the Global Circulation Models CGCM3.1 obtained from DAI, Data Access integration/Canada that contains Gridded atmospheric variables were used in this model .

1.5 Importance of Study

Draughts and floods are one of the most phenomena resulting from climate change and these two events is a result of precipitation rate. It can be acknowledged from several studies that dry regions are suffering from further draughts while tropical regions are experiencing much rainfall rate. The rainfall stations are located in Pahang state in Malaysia and it falls in a tropical region where suffering from extensive rainfall. Therefore, the importance of this study is to project rainfall amount for the region and the results obtained would be helpful for decision makers and water managers.

1.6 Project Outline

This project consist of six chapters. Chapter one consist of the introduction, problem statement, objectives and scope of the study. Chapter two talks about climate change, General Circulation Models and downscaling methods. Chapter Three discuss the methodological approach of the study by using Automated Statistical Downscaling tool (ASD). Chapter four describes the study area, data description and data collection. Result discussion is elaborated in chapter five. Finally, chapter six is the conclusion remarks and recommendations.

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